International Journal of Chemical & Petrochemical Technology (IJCPT)
ISSN(P): 2277-4807; ISSN(E): 2319-4464
Vol. 4, Issue 1, Feb 2014, 31-36

A BATCH STUDY ON THE REMOVAL OF NICKEL (II) USING LOW COST ADSORBENT FLYASH

S. LAKSHMI NARAYANAN[1], C. ARUNKUMAR[2], R. PERUMAL[3], P. K. SARAVANAN[4] & A. S. ARUN PRASAD[5]

[1]Department of Chemical Engineering, Erode Institute of Chemical Technology Polytechnic College, Tiruppur, India

[2,3,4,5]Department of Petrochemical Technology, Sri Ramanathan Engineering College, Tiruppur, India

ABSTRACT

The present study is to investigate the removal of Heavy metals Ni (II) from the Industrial effluent using Fly ash emitted from the power plant. Fly ash is used as an adsorbent for the removal of Ni (II), in which various parameters such as Adsorbent Dosage, Contact time, pH and Initial Concentration are studied. The adsorption data using Langmuir and Freundlich Isotherm are analysed that concludes Fly ash is the best adsorbent for the removal of Heavy metals Ni (II).

KEYWORDS: Fly Ash, Batch Adsoption Studies, Ni (II) Removal, Langmuir and Freundlich Isotherm

INTRODUCTION

In recent years, the progressive increase of Industrial and Technological development that causes various types of pollutants to the Environment and Human life (Torab- Mortaedi *et al.,* 2010). The Industrial waste water contains toxic pollutants which contaminate the ground water and it contains heavy metals such as Al, Ni, Zn, Pb, Cd, Cu and So on, one among those is Ni (II) a toxic heavy metal have good conductors of Heat and Electricity and high corrosive resistant that are widely used in Silver refineries, Electroplating and Storage battery Industries (House Croft and Sharpe, 2008). During this process, the Ni (II) released onto the effluent which causes Head-ache, Nausea, Chest Tightness, Chest pain, Lung Cancer, Respiratory failure and allergic reactions (Hema Krishna and Avvs Swamy, 2011; Parker, 1980).

There are several physical and chemical methods have been employed for the treatment of contaminated wastewater with heavy metals, among these adsorption with the suitable adsorbent would be an effective technique for the removal (Lakshmi Narayanan *et al.,* 2013). The solid wastes generated from various industries can be beneficiary utilized as low cost adsorbent which controls the environmental pollution (Nhapi *et al.,* 2011). Fly ash is an adsorbent contains particulate material produced by the combustion of coal at Thermal power plants which is collected with Cyclones or Electrostatic precipitators (Ahmaruzzaman, 2010; Wang and Wu, 2006). The present study aimed for the removal of Ni (II) using the Industrial Adsorbent Fly ash and to optimize the parameters such as Adsorbent dosage, Contact time, pH and Initial Concentration, then the equilibrium data for adsorption is explained by Langmuir and Freundlich Isotherms.

MATERIALS AND METHODS

Preparation of Fly Ash for Adsorption Studies

Fly ash used in the present study is obtained from Thiru Arooran Sugar Industry, Thanjavur, India. The constituents of Fly ash are SiO_2- 55.04%, Al_2O_3- 24.90%, CaO- 2.3%, Fe_2O_3- 8.18%, Mgo- 0.89%, So_3- 0.75%, Tio_2- 0.72, K_2O- 0.55%, others- 6.69% which are analyzed in Growell Technologies, Chennai, India. The collected adsorbent (Fly ash) is sieved by various size sieve shaker; finally 250 micron size particles are used for further experiments.

Preparation and Analysis of Ni (II) Solutions

All the Chemicals, except water are purchased from Hi-Media and used without modification. Distilled water is obtained from Milli–Q water system (Millipore Corporation) and filtered to remove any impurities. The stock solution is prepared by dissolving 4.48g of anhydrous Nickel sulphate in one litre of distilled water, the final concentration of Ni (II) solution is 1000ppm, from that it is further diluted with distilled water to the desired concentration for obtaining the test solution of 100 ppm and used for further studies. The Initial and Residual concentration of Ni (II) is analysed using UV double beam absorption spectrophotometer (LABINDIA-UV3092).

Batch Adsorption Studies

In Batch Adsorption studies the various parameters are analysed for the adsorption of Ni (II) such as Adsorbent dosage, Contact time, pH and Initial Concentration and the kinetic studies by Langmuir and Frendlich Isotherms are evaluated. The experiments are conducted in the conical flask, where the known quantity of Adsorbent (Fly ash) is taken with 100 ml of Ni (II) solution and it is agitated at the speed of 150 rpm in a rotary shaker. The filtrate is removed from the adsorbent solution using filtration and the percentage removal of Ni (II) is determined by UV Spectrophotometer at the wavelength of 394 nm.

The amount of Ni (II) adsorbed by the adsorbent and the percentage removal of Ni (II) are calculated using the following Equations:

$\mathbf{Q = (C_0 - C_e)}$

Removal Percentage of Ni (II) = $\mathbf{C_0 - C_e / C_0 \times 100}$

Where,

Q - Adsorption capacity of Fly ash

Co-Initial concentration of Nickel

C e-Residual concentration of Nickel

RESULTS AND DISCUSSIONS

Effect of Adsorbent Dosage

The adsorbent experiment is carried out for the removal of Ni (II) by varying the adsorbent dosage of fly ash from 2 to 12 g at room temperature at pH 8 is taken in a 250ml conical flask and kept at orbital shaker for 120 min. The absorbance of the filtered solution is measured by UV- Spectrophotometer at 394 nm and the graph is plotted between Adsorbent Dosage VS Percentage removal of Ni (II) solution as shown in Figure 1. The result in the percentage removal of Ni (II) is obtained as 76.84 % to 12 g of Fly ash and further addition of adsorbent did not cause any change in the removal efficiency, this may due to the overlapping of adsorbent at the adsorption sites (Namasivayam *et al.*, 1998).

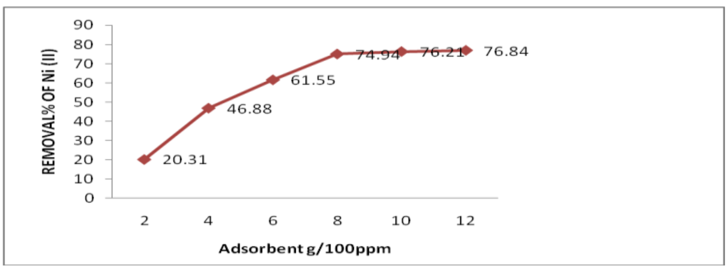

Figure 1: Effect of Adsorbent Dosage vs Percentage Removal of Ni (II)

Effect of Agitation Time

The adsorption studies for the removal of Ni (II) is carried out by agitating the Initial Ni (II) concentration (100 ppm) with optimum fly ash of 12g at pH 8 by varying the contact time from 15 to 90 minutes. The percentage removal of Ni (II) is 70.89 % at 90 min is measured and the graph is plotted between Contact time VS Percentage removal as shown in Figure 2. The rate of Ni (II) removal is higher at the initial stage is due to the larger availability of active sites in the adsorbent and it reaches equilibrium constant after 90 min due to the lesser availability of active sites (Senthil kumar and Kirthika, 2009; Emine Malkoc and Yasar Nuhoglu, 2005).

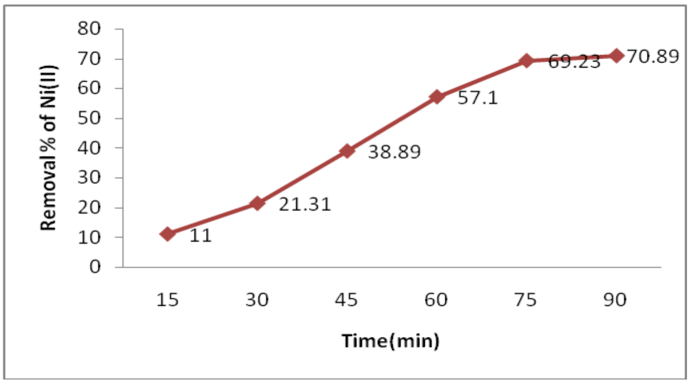

Figure 2: Effect of Agitation Time vs Percentage Removal of Ni (II)

Effect of Initial Concentration

The effect of Initial concentration for the removal of Ni (II) is observed by varying the concentration of Ni (II) solution from 20 to 100 ppm under specific condition at pH 8, contact time 90 min, adsorbent of 12 g and at room temperature. The graph is plotted between Initial Concentration VS Percentage removal as shown in Figure 3. from which the maximum and minimum removal efficiency of Ni (II) is observed at 90.5% for 20 ppm and 70.7% for 100 ppm. The removal percentage is higher with lower initial concentration, then the higher concentration is due to the availability of more adsorption binding sites at the initial stage (Singh *et al.*, 2009; Lokendra Singh Thakur and Mukesh Parman, 2013).

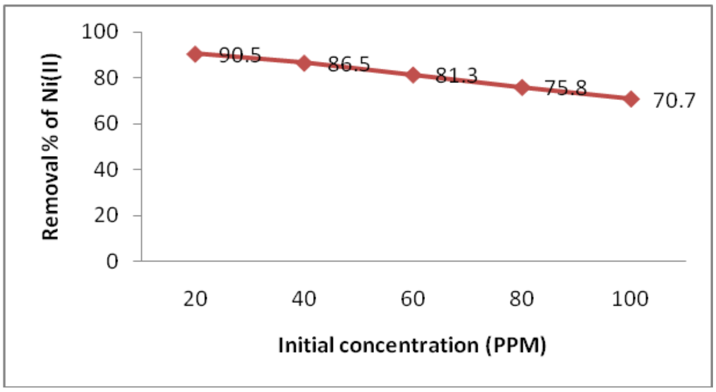

Figure 3: Effect of Initial Concentration vs Percentage Removal of Ni (II)

Effect of pH on Adsorption

The batch studies are carried out to obtain optimum pH for the adsorption of Ni (II) using Fly ash by varying the range from pH 1 to 9 under specific conditions. The graph is drawn between different concentrations of pH VS Percentage removal of Ni (II) as shown in Figure 4, which shows the maximum removal at pH 6 as 71.16 %. The removal percentage increases up to pH 6 after that the removal efficiency is decreased to the H^+ and OH^- ions present in the solution (Manjeet *et al.*, 2009; Elovear *et al.*, 2010; Malarvizhi *et al.*, 2013).

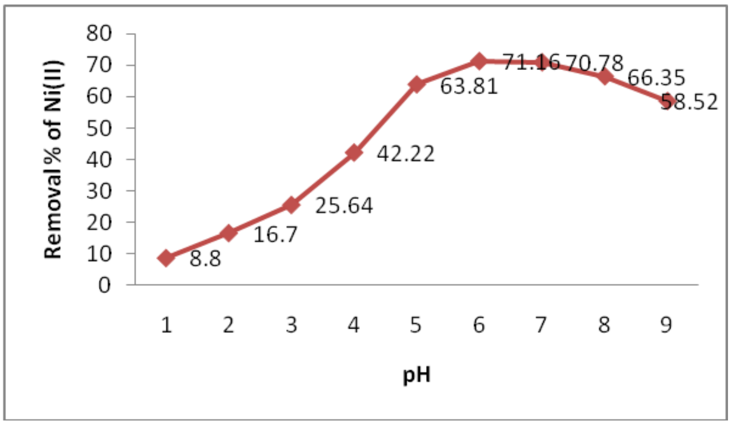

Figure 4: Effect of pH vs Percentage Removal of Ni (II)

Adsorption Isotherms for Batch Studies

Adsorption Isotherms are the mathematical models describe the metal uptake per unit weight of the adsorbent to have an equilibrium concentration of the adsorbate in the liquid phase (Rio *et al.,* 2002). In the present study the obtained results in the adsorption of Ni (II) on to Fly ash are analysed using the known models such as Langmuir and Freundlich that are connected with the amount of adsorbate on the adsorbent.

Langmuir Isotherm

Langmuir model is the theoretical model describes the adsorption of Adsorbate (A) onto the surface of the Adsorbent (S) (Valli *et al.,* 2006). The Langmuir isotherm equation is derived from rational consideration and is given by,

$$\mathbf{1/(X/m) = 1/q_m + 1/K_A . q_m\ (1/C_e)}$$

Where, X/m is the amount adsorbed per unit weight of adsorbent Fly ash (mg/g), $K_{A,}$ q_m are constants, K_A is the Rate of adsorption, q_m is the adsorptive capacity of Fly ash, C_e is the equilibrium concentration of the adsorbate in solution after adsorption (mg/l). A graph **1/Ce VS 1/(X/m)** is plotted (Figure 5) and the value of K_A=0.2697 and q_m = 0.00102 are calculated. The Langmuir isotherm can be expressed in terms of a dimensionless value $R_{L,}$ is defined as

$$\mathbf{R_L = 1/\ (1+ K_A.C_o)}$$

Where, C_o is the Initial concentration (mg/l) R_L is the Indicates the isotherm. There are four probabilities for the values of R_L as shown in Table 1. The values of R_L is 0.033 for the studied system at different dosage were found to be in between 0 to 1 which indicate favorable adsorption of Ni (II) onto the adsorbent Fly ash (Pandey *et al.,* 2007; Senthil *et al.,* 2007; Hema Krishna and Avvs Swamy, 2011).

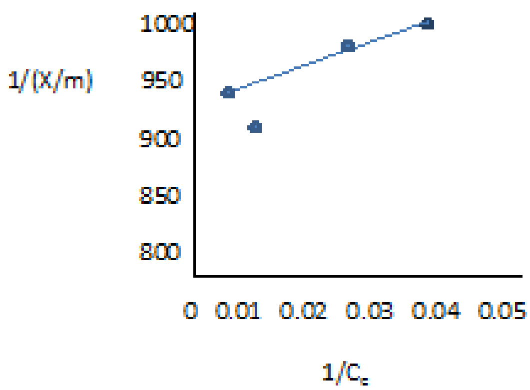

Figure 5: Langmuir Isotherm

Table 1: Comparison Ranges of R_L Values

R_L	Type of Isotherm
$R_L > 1$	Unfavorable
$R_L = 1$	Linear
$0 < R_L < 1$	Favorable
$R_L = 0$	Irreversible

Freundlich Isotherm

Freundlich isotherm model can be applied for heterogeneous surfaces and the linearized freundlich model isotherm was applied for the adsorption of Ni (II) (Freundlich, 1906) and is expressed as

$$\text{Log } (X/m) = \text{Log } K_F + 1/n \, (\text{Log } C_e)$$

Where, (x/m) is the amount of Nickel adsorbed at equilibrium (mg/g). C_e is the equilibrium concentration of Nickel in solution (mg/l). K_F and n are the constant values are calculated from the intercept and slope of the plot (Figure 6). To evaluate the constants, a logarithmic plot of **Ce VS X/m** was made and a linear relationship is found and the value of the intercept of the figure is Log K_F= 0.00093. The slope of the line will give the value of 1/n= 0.278. The value of K_F indicates the adsorption capacity and n denotes the adsorption intensity. The result indicated that the adsorbent has several different types of adsorption sites and the calculated n value 3.5 indicate good adsorption of Ni (II) on Fly ash (Abdel- Razek, 2011; Nwabanne and IGabokwe, 2012; Malarvizhi *et al.*, 2013). Log C_e

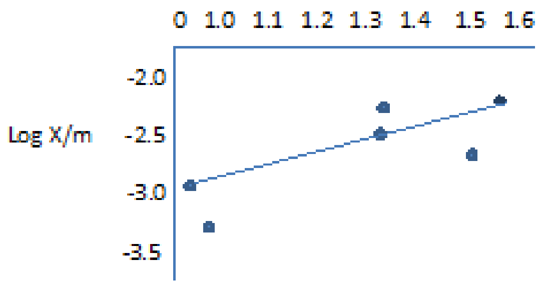

Figure 6: Freundlich Isotherm

CONCLUSIONS

In the present study, Adsorbent (Fly ash) is selected for the removal of heavy metals of Heavy metals Ni (II) using Adsorption studies. Batch experiments are conducted using various parameters such as Adsorbent Dosage, pH, Initial Concentration and Agitation time. The maximum percentage removal Ni (II) is 76.84% with the adsorbent dosage of 12 g. The equilibrium agitation time for the percentage removal is 70.89% at an optimum time of 90 minutes that shows the reduction of Ni (II) increases with an increase in the agitation time. The maximum and minimum removal of Ni (II) on to the adsorbent is 90.5% for 20 ppm and 70.7% for 100 ppm which shows the removal percentage is maximum at lower concentration. The higher percentage removal of Ni (II) at pH 6 is 71.16% that shows the removal efficiency is minimized due to H^+ and OH^- ions present in the solution. The Langmuir and Freundlich Isotherms are studied for the adsorption studies and shows that the adsorbent selected for this study proved to be good adsorbent for the removal of Heavy metal Ni (II).

ACKNOWLEDGEMENTS

The authors thank the Principal and Department of Petrochemical Technology, Sri Ramanathan Engineering College, Tiruppur, India for providing Laboratory facilities.

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